GEOGRAPHICAL ILLUSTRATIONS

SUGGESTIONS FOR TEACHING PHYSICAL GEOGRAPHY BASED ON THE PHYSICAL FEATURES OF SOUTHERN NEW ENGLAND

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INTRODUCTION.

The descriptive geography of a region gives us an account of its various parts, such as rivers, valleys, hills, and mountains, independently of one another, except as to relative position. It deals largely with statistics of length, height, and area. In its more political chapters, it tells of the place, size, and business of cities and states.

Physical geography deals with the same subjects, but seeks to consider them in their natural relations. It recognizes that the surface of the earth has been fashioned by natural processes, and that it now stands in a transient stage between its past and its future. It perceives that certain features of the surface are newly made, and that others are the product of long-continued processes; and in this difference it finds useful means of giving reasonable understanding to the subject. It includes a consideration of the occupation of the earth by man as one of the most interesting chapters in natural history, and it therefore takes particular care to distinguish those conditions which determine man's settlement and occupation.

A subject so comprehensive as this, must needs be treated in a carefully chosen and systematic order, if confusion is to be avoided; and I therefore introduce in brief form a statement of the scheme under which the various parts of the land are, to my mind, most simply placed in their natural relationships, and thus most conveniently grouped for study.

It is well understood that every part of the surface of the land has a form dependent on the interaction of two kinds of forces, the one constructive, the other destructive. It is, therefore, important to begin with a conception of land forms such as they would be if determined by constructive processes alone. The accumulation of a sand dune is a minute example of such a process; the heaping of a terminal glacial moraine is another; the heaping of a volcanic cone is a much larger example; the uplift of a broad plateau involves an enormous mass of earth crust; and the crushing together and uprising of a mountain range give us the climax of these constructive operations.

As soon as land form is thus constructed, the destructive processes of the atmosphere attack its surface. The waste thus produced creeps and washes down the slopes, and the streams and rivers then carry it to its goal in the sea. Time is so long that even the loftiest constructional forms must in this way be reduced to lowlands, if the destructive processes go on without hindrance or interruption; and between the constructive beginning and the far distant completion of the destructive denudation, there is a whole sequence of forms to which the adjectives young, adolescent, mature, and old apply most appropriately.

When their meaning is once perceived, the student will not willingly give up their use.

The succession of features attained by any land area will depend, then, in the first place, on its initial constructional forms: it may begin as an even plateau surface, as a volcanic cone, or as a series of mountain ridges. The features will depend, in the second place, on the degree of advance made by the destructive forces in wearing away all that part of the mass which stands above sea-level, or above "baselevel," as it is more conveniently expressed. An adolescent plateau is different from an adolescent mountain range; an adolescent plateau is also different from an old plateau.

A similar plan may be followed in considering the features of coast lines. When a change in the relative attitude of the land and sea brings the waters to reside at a new level, the outline of the coast may be called constructional. As long as the land stands still, the littoral waves and currents work upon it and effect progressive transformation of its outline, thus carrying it through successive stages that may be called young, adolescent, and mature as before.

There are two qualifications of this scheme which must be noticed, rather to avoid misapprehension than to present the scheme completely. The first is that the destructive processes do not hold back their attack until the constructive processes have completed their work. Destructive denudation begins as soon as any part of a land mass rises above sea-level. If the constructive processes are relatively slow, a considerable advance may be made by the destructive processes

before construction ceases; but as far as the facts are now understood, the greater part of the task that is set before the latter still remains undone after the former have completed their work. It is, therefore, fair in a general way to separate with some distinctness the two stages, constructive and destructive, in the history of any land area.

The second qualification is that we need not imagine every constructed land area to stand still, suffering continually from the destructive forces, until it is completely denuded to baselevel. If no disturbance took place, the time required for complete denudation would be called a complete geographical cycle. But a renewal of constructive upheavals, or deformations, may be introduced at any stage in the destructive development of a land mass. The forms then reached by the constructive and destructive processes of the first incomplete cycle serve as the constructional or initial forms of the new cycle, and from this beginning the destructive forces then proceed again. Thus land areas frequently present what may be called composite topographic forms, part of the surface having been shaped during an earlier cycle of destructive development, and another part being the work of later destructive work, while the land mass stood at a different attitude with respect to baselevel. The discrimination of the different parts of a composite landscape affords one of the most interesting tasks that a geographer can undertake. Composite topography is illustrated in great variety and with surprising distinctness in New England.

It is manifest that the study of physical geography

on such a scheme as this implies an understanding of physical geology. There can be no question that this is essential for any proper advance to a good treatment of the subject. Indeed, I believe that the chief cause of the slow progress of physical geography in the text-books and in the schools is due to the weakness or absence of this fundamental subject. No great amount of study is needed for its acquisition; nothing need be said about fossils or about the ages of the world; but the general principles of changes of level, deformation, volcanic action, and especially of denudation, must be clearly in the mind of every teacher who would gain a rational understanding of physical geography.

Let us take southern New England as a field in which to look for illustrations of a systematic method of treating physical geography.

THE PHYSICAL FEATURES OF SOUTHERN NEW ENGLAND.

On ascending the summit of any of the hills in southern New England, the most characteristic feature of the view is the comparative evenness of the horizon line. From one upland to the next there is small change of height. The successive uplands are more or less widely separated by valleys, like those of the Blackstone or of the Connecticut, which are sunk beneath the general upland level; and occasional mountain-like eminences rise above the general upland surface, as the Blue Hills, Wachusett, and Monadnock. But both the valleys and the mountains are only local departures from the relatively continuous upland sur-

face. The truth of this is not so well perceived in south-eastern New England as when one goes further north and west, where the upland gradually ascends to greater height, as if it were a gently inclined plain. On the Berkshire plateau, for example, the rolling upland is the dominating feature of the country. The higher mountains are merely elevations above it. The valleys are merely incisions below it.

Rhode Island lies in the southern part of this slanting upland, with a great indentation of its coast line forming Narragansett Bay. Our attention to-day will be turned particularly towards Rhode Island,—first, because we meet within its limits; second, because this state has been so well mapped, and its map is now so widely distributed to its schools and libraries.[1] Massachusetts has a similar map in many separate sheets.[2] Connecticut is surveyed, but the maps are not yet published.

In what order shall we consider the smaller topographic forms by which the larger features of the region are diversified? The natural order for their consideration would be that of their development, but the simpler order for our use is the reverse of this; and in the following description I shall begin with the very youngest of the minor features of Rhode Island, and follow backward to the older ones, coming finally to the plateau itself.

[1] Topographical map of the state of Rhode Island, by the U. S. Geological Survey in coöperation with the state, 1891. For sale by J. C. Thompson, 269 Westminster street, Providence, R. I. Continual reference should be made by the reader to this map.

[2] Topographical Atlas of Massachusetts, published by the state.

THE SAND BARS AND CLIFFS OF THE COAST LINE.

Along the southern coast of the state there are numerous sand bars swinging from headland to headland in long curves concave to the ocean.[1] The two bays known as branches of the Westport river, a little east of the Rhode Island border, are enclosed by such a bar. Sachuest Island is attached to Aquidneck Island by a pair of such bars, enclosing a small lagoon between them. Westward from Point Judith the comparatively simple outline of the coast depends almost entirely on the sand bars, behind which a number of ponds and salt marshes are held back against the irregular margin of the mainland. These bars are all a product of work by the sea-shore waves. Their material comes, in part, from the shallow bottom of the ocean, close to the shore, where the sands are scoured up and carried into still shallower water; and, in part, from the headlands that receive the stronger beating of the waves, and are thus cut away backwards, the material taken from them being washed along shore in one direction or the other. Inasmuch as the great volume of littoral water moved by the waves and currents cannot swing around the sharper corners of the coast, but prefers to move in long sweeping curves, the growth of the sand bars is so ordered as to produce a smoother outline than that of the coast on which the waves first beat; the headlands are somewhat worn back into cliffs, while sand bars are built across the

[1] This part of the address was illustrated by a generalized bird's-eye view of the state of Rhode Island, drawn roughly in colored chalks on a blackboard.

bays, thus tending to simplify the coast line from its original inequality; the change thus far made is of moderate amount; it is an adolescent coast line.

In Rhode Island the sand bars are of but moderate size, but they deserve our careful attention, first, because of their existence here in so characteristic a development, and secondly, because, by means of their occurrence here on a small scale, we can best appreciate their occurrence elsewhere on a much larger scale.

Just as the bays of Westport river are enclosed by a curved bar, built from the headland on the west, so the harbor of Duluth is shut in from the main water body of Lake Superior by a bar springing from the north shore; so the Kurish harbor of the Baltic is cut off from the parent sea by a sand bar, but the last is perhaps thirty times the size of the first. Just as the little Sachuest Island is attached by a pair of sand bars to the larger Aquidneck Island, which serves it as the mainland, so the once isolated rock of Gibraltar has been welded to the mainland of Spain by a low strip of sand; and the English occupants of the Rock know very well that the difficulty of its fortification is thereby greatly increased. Without the sand, it could be attacked only from the sea, but now it may be attacked by land.

A larger instance of the same kind is found in the attachment of the rugged island on which Cape Town, Table Mountain, and the Cape of Good Hope are situated, to the mainland of Africa. But perhaps the most interesting of all instances of this sort is seen in the Island of Ceylon; here the shifting currents, drifted

one way and the other by the shifting monsoon winds, alternately build a bar from the southern and from the northern points of the island toward the mainland of India. There is no thoroughfare for vessels behind Ceylon. The southern of the bars is already built up close to sea-level, and has become the site of active coral growth. In some places the sands surmount the waves and form an almost continuous pathway from India to Ceylon. It has the name of "Adam's Bridge," being connected by local story with the traditional father of our race. The northern bar is not so far advanced as the southern, but its successful beginning is clearly shown by soundings. It needs but a short glance into the geographical future to see the time when the two bars will be wholly completed, and the enclosed bay will be the perfect analogue of the little lagoon behind Sachuest Island. How greatly is pleasure stimulated and rational memory aided by comparisons of this kind! How useful that insignificant little Sachuest Island becomes when it is seen to be a small member of a large family with relatives all around the world!

The long bars which shut up the ponds west of Point Judith may be closely compared with the great series of sand bars that skirt the southern coast of Long Island, and that may be followed, with little interruption, from New Jersey all along our Atlantic and the Gulf coast, even to Mexico. In many cases, however, the bars along the southern Atlantic coast are not attached to the mainland at either end, and must therefore be regarded as the product only of scouring from the shallow sea bottom. The sand bars of New Jersey have a large population of summer visitors, who

fly from the heat of the interior cities to the cool sea breezes on the shore.[1]

Albemarle and Pamplico Sounds, enclosed by extensive off-shore sand bars, are hardly more than larger examples of the little ponds behind the bars of Point Judith. Capes Hatteras, Lookout, and Fear are cusps of sand, formed where the ends of adjacent bars, concave to the ocean, unite and point out to seaward; lightships are anchored off the coast where the sands are drifted out from the cusps, forming dangerous shoals. The southern coast of Texas possesses, in Padre Island, one of the longest sand bars in the world. Beautiful illustrations of all these examples on our own coast may be had at very moderate cost in the charts published by the U. S. Coast Survey. Their average price is fifty cents each.[2] If the school board cannot provide these for class use, let each class contribute to a fund sufficient to buy one or two charts in a year; or let some local benefactor of the school lavish a few dollars a year for the increase of this kind of illustration. It may be added that the illustrated catalogue of the charts published by the Coast Survey may be had by any responsible person, free of charge, on application to the superintendent at Washington.

The cliffs that have been cut on the headlands from which the sand bars of Rhode Island are hung, attain

[1] Sample sheets of the topographical atlas of New Jersey were exhibited in illustration of these features. The sheets may be obtained singly for twenty-five cents and postage; or the entire atlas of twenty sheets for five dollars, from the Geological Survey of New Jersey, Trenton, N. J.

[2] Several charts of this series were exhibited during the lecture.

no great magnitude in this little state, yet they may serve to introduce cliffs of greater height in other parts of the world. The chalk cliffs of southern England, visible from the opposite shore of France, gave the name of Albion to our forefathers' land. The cliffs of western Ireland and Scotland, and of the Shetland and Orkney Islands, are only larger examples of coast action. Here the great waves, driven on the coast by the westerly winds of the stormy north Atlantic, have cut away miles of land and carved out sea cliffs that have no rival on our windward coast of the same ocean. Many a wreck attests the dangers of these rock-bound coasts; many an English story turns on their headlands and bays.

In order to emphasize the fact that the cliffs are made by cutting back the headlands, and that the bars have been thrown across the inlets in the progressive simplification of the coast line, we should draw a sketch map, from which the bars are omitted, and on which the headlands are built out to sea again, restoring something of their former extension.[1] The shore line would then have more nearly the form that it possessed when the sea first came to lie upon it, and in this simple manner a lesson may be given of the changes promoted by the sea, as it beats on the land. The partial simplification already reached in the adolescent coast line of Rhode Island must come to be even more advanced in future, when the greater headlands are pushed further back and when the larger bays are at last enclosed.

[1] The blackboard sketch mentioned in a previous note was, at this point, modified to illustrate such a change.

The future coast of Rhode Island is already realized in the almost mature features of the greatly simplified coast line of eastern Maryland. Here the ocean sees no vestige of any original irregularity in the shore line; the sea margin is reduced to an even line by cutting off the headlands and building the bars. When the cliffs and bars are pushed further in by the advance of the consuming waves, and the lagoons that now lie behind the bars are destroyed, the coast may be called fully mature. The successful development of an adolescent or sub-mature coast line is also beautifully shown on the sandy southern coast of Martha's Vineyard, where the originally ragged headlands have been snubbed back into a line of low cliffs, perfectly continuous east and west with that of the bars which have converted the heads of the former bays into ponds. It is noteworthy that both of these sub-mature coasts are carved on lands of weak materials, where the development of a mature outline has been relatively rapid. Such maturity is seldom discoverable on rocky coasts; and hence we may infer that the land does not stand still long enough for a great piece of work to be effected by the sea on a resistant coast at a single level.

It ought to be said here, that, in telling about changes of the coast line in the preceding paragraphs, and about other changes in the pages that follow, it is not the intention simply to inform our pupils about what the land about us has been and will be, but rather to impress upon them the real meaning of the land as it is now, and to reveal to them the natural relationships that exist between our home dis-

trict and various other parts of the world that are like or unlike to it. It is not so important simply to know that the headland of Point Judith once extended farther out to sea, as it is to appreciate the bearing of this local fact on the characteristics of various coast lines that are in different stages of development. Thus understood, the study of geographic development is as important in guiding us to a true classification of geographical forms as the study of biological development is in leading to the natural classification of organic forms.

FEATURES DEPENDENT ON GLACIAL ACTION.

Leaving now the coast for a time and passing inland, the youngest features of the land are found in the swampy fillings of various hollows that not long ago held clear ponds of water. These are very numerous in certain parts of the state. Closely associated with the filling of former ponds by swamp growth on their bottom, is the progressive deepening of their outlets through gravel beds along the stream courses, whereby the former water level has been lowered. The occurrence of marshes should probably be ascribed somewhat more to the latter than to the former of these processes. Sweep out the marshy deposits, fill up the channels now cut through the terraced gravel beds along the outlets, and many a marsh would become a pond, and many a pond would be larger and deeper than it is now. Ponds are still plentiful in Rhode Island, but not so plentiful as they were a little earlier in the development of the state. When the shore line possessed its original irregularity, the ponds

of the state probably existed in two or three times their present number and volume.

The gravel and sand taken away by the streams in deepening the outlets of the ponds would have served to form deltas of appreciable size where the streams flow into Narragansett Bay, were it not that no waste of the land has been able to pass below the lowest surviving pond on each stream. Every pond acts like a filter to the stream that enters it; hence the greater part of the sand and gravel taken out of the valleys by the streams have not reached the bay, but have stopped on the way. If the streams had united into a large river, a delta might have been already formed at its mouth; but none of the rivers entering the bay are of even medium size. If the streams, even with their present small size, had worked a long time, the land standing still all the time, then we should find deltas well advanced: but we are already persuaded that only a moderate time has been spent by the sea on its present shore line; hence it is natural that the little rivers have not yet made significant deltas; nearly all the streams are still in the estuarial stage of their existence.

The Thames, the Connecticut, the Hudson, the Delaware, the Susquehanna, the Potomac, and many other rivers of our Atlantic slope are like the little streams of Narragansett Bay in this respect. The absence of deltas at their mouths is in part due to the scouring action of the tides, but it must be in much greater part explained as a consequence of the brief residence of the sea at its present level on the land slope. The rivers themselves are quite old enough to

have deltas, but the present positions of their mouths have been so lately determined, either by a rising or a sinking of the land with relation to the sea, that no deltas have yet been made in the present cycle of shore development.

In this connection, we may use the principle of contrast as well as that of likeness in extending our study from Rhode Island to other parts of the world. The very absence of deltas at the mouths of our New England rivers leads by contrast to the mention of the magnificent delta at the mouth of the Mississippi. The delta is well known; perhaps it is not equally well known that the superbly engraved chart of the delta may be had of the United States Coast Survey for a merely nominal cost.

The origin of the ponds and of various features associated with them is a matter of much more importance than it would at first appear to be, and this study will lead us to the consideration of many other matters. Westward from Point Judith we find a range of gravel hills, extremely irregular in shape, and equally irregular in materials. They are built up of loose rock of all grades of texture, from fine sand to great boulders, commonly known as *drift*. The material is tumultuously strewn about, as if it had been laid in a very disorderly fashion upon a rock foundation below.

Irregular gravel hills and broad deposits of washed sand are very common all over Rhode Island, and indeed all over New England.

If all these loose, superficial deposits of drift were removed, several significant changes would be made in the form and outline of the state. In the first place,

the waters of the sea would advance over the places now occupied by the gravel hills west of Point Judith; the shore line would be found somewhere north of the present course of Pawcatuck river. The ponds and the marshes that now lie behind the gravel hills would then be the marginal part of the ocean, and Rhode Island would be shorn of a considerable fraction of its small area. The several head branches of the Pawcatuck, now flowing southward to join the main stream where it turns west through the ponds and marshes, would then have entered the sea independently as so many separate little rivers. We are familiar with slight artificial additions to land areas in building wharfs, or, on a larger scale, in filling in the back bay at Boston; but the wholesale addition of many square miles to the area of a state by building its surface out into the sea is certainly a novelty.

Surface deposits of sand and gravel drift have been described as widely extended over all parts of the state. Every traveller by road or by rail has seen them. They occur particularly in the valleys, where they have, over and over again, effectively obstructed the course of streams, holding them back in ponds, turning them aside from their former courses so that they must flow over rocks and ledges, from which they now descend in cascades and waterfalls.[1] Evidently the state would be vastly changed if all these loose

[1] Two paper relief maps were shown in explanation of the contrast between normal drainage by uninterrupted streams, and imperfect drainage by streams obstructed by drift and held back in ponds: the first typifying the present drainage of North Carolina or the former drainage of New England; the second typifying the present drainage of New England, Canada, Finland, and similar lacustrine regions.

gravels were stripped from its surface and returned to the hills and ledges whence they have been dragged away. There would be no marshes or ponds; there would be no waterfalls; the streams would be greatly re-arranged from their present courses; the sea would reach farther inland than it does now at many points.

This extraordinary work of strewing the state with sands and gravels was accomplished during the time when Rhode Island, and indeed all of New England and the greater part of the northern United States were deeply sheeted over by a covering of ice such as is now seen in Greenland. The present physical features of Greenland are therefore of particular interest to the student of New England's form. The inland ice sheet of that Arctic land has lately been visited by several explorers, notably by Nansen,[1] and their accounts of its monotonous, barren, almost level surface gain an especial value when it is understood that New England was lately—in a geographical sense—sheeted over by a similar plain of ice and snow. I cannot here stop to consider the many lines of logical evidence by which this remarkable conclusion is supported, but I desire to call particular attention to it as an essential element in the description of the present physical features of our states. Whatever the cause that brought this singular invader down upon us from the north, there is no reasonable doubt that it came. It crept slowly along, weighing heavily on the ground below, dragging along all the loose soil that it found ready made on the land, and

[1] Since this address was delivered, we have news of Peary's success in penetrating northern Greenland.

detaching many a boulder from projecting ledges. It gradually rounded off the minor asperities of the hills and slopes; it deepened the valley troughs along which it flowed: but while these changes were of significant value, they must not be exaggerated. Glacial erosion nowhere reached the excessive measures that were allowed it twenty or thirty years ago. The heavy ice sheet, pressing down on the rock over which it slowly crept, acted after the manner of a great rasp, gradually rubbing down the minor inequalities of the surface. A considerable volume of loose material was successively dragged or carried along by the ice, or washed along by the numerous streams that flowed along beneath it; and thus heavy and irregular accumulations of land-waste were formed along the lines maintained by the ice front for any considerable time. Such deposits are called terminal moraines.

The range of irregular hills near the coast westward from Point Judith, affords one of the best illustrations of this type of land form that is to be found in the country; it is clearly portrayed on the contour map of the state, and being easily reached, it should come to be a type of terminal moraines in our teaching. It may be traced westward, crossing Long Island Sound by Fisher's Island, running along the backbone of Long Island itself, and forming the Narrows by which the lower and upper harbors of New York city are separated. Its course may then be followed more or less distinctly through New Jersey, Pennsylvania, and further west, even beyond Minnesota into Canada.

Southward and eastward from Rhode Island, a series of morainic hills is found on Block Island, Martha's

Vineyard, and Nantucket, on the Elizabeth Islands of Massachusetts, and along the curved arm of Cape Cod. A considerable extent of land has thus been added to the south-eastern part of the old Bay State. While we cannot at present accurately define the relations of these morainic belts, yet it may be safely asserted that all of them were deposited after one or another of the onward movements of the ancient ice sheet. They are all of one pattern, and better deserve recognition than the little sand dunes on our larger coastal bars. And yet it is more usual to hear in our geographies of sand dunes than of drift moraines. The former are the more important in the remote Sahara; the latter are more important at home.

Most of the drift beneath the ice sheet was not brought all the way to the margin of the ice. It still remains spread over the country north of the moraines. Much of it is firmly compacted, as if by gradual accumulation under the pressure of the heavy ice sheet that dragged over it. Sometimes it locally forms long hills with a thickness of fifty, a hundred, or more feet: its surface outline then flows in long, smooth curves. These hills characterize Aquidneck Island, north of Newport, where the gentle modulation of the landscape is almost wholly the product of creeping ice. Similar hills often attain a greater development further inland, rising to summits of one or two hundred feet in height, with an oval outline of half a mile, more or less, in length, and an average ratio of perhaps three to one between the longer and shorter axes of the base. Hills of this nature are now commonly known by the name of drumlins, a term imported especially from

Ireland, where it was first applied to drift masses of this kind. Drumlins are easily recognized by their smooth, convex outline, and often by their being cleared of trees and used for farming in preference to the much more rugged and ledgy hills on either side. The absence of gulleys on their slopes assures us that denudation has as yet effected but little change in their original constructional form. The same lesson is taught by the unfilled hollows among the hills of the moraines. The glacial drift has therefore been lately laid upon our land: its forms have advanced but little in their cycle of destructive development. They are very young. It is only where active streams run across them that they are significantly altered.

The drumlins in the neighborhood of Boston constitute striking features in the landscape. One of the best marked is known as Corey's Hill, in Brookline, a conspicuous object in the view south-westward across the Charles River from Cambridge. Other hills of even greater height occur in Chelsea and beyond. Many of the drumlins on the coast have been cut back into sea cliffs, such as those of Grover's Head and Winthrop Head, north of Boston. Some of the drumlin islands in Boston Harbor are tied to the mainland by long sand bars, as at Nantasket. Further inland, remarkable groups of drumlins are seen about Pomfret, in north-eastern Connecticut, and in the upland district between Charlton and Spencer, where the Boston and Albany Railroad reaches its highest elevation between Worcester and Springfield. If we had volcanoes in New England, what geographer would fail to mention them? Drumlins are as peculiar and as

easily recognized as volcanoes; they may be counted by the hundreds: should we not therefore give them some attention in our elementary teaching?

Returning to Rhode Island again, we may briefly consider those loosely compacted glacial sands and gravels, frequently with a more or less even upper surface, whose deposit is associated with the closing stages of the ice period. Among the most important of these are the deposits of sand and gravel that are washed down the larger valleys. Rhode Island contains no conspicuous example of this class, but the Merrimack valley in New Hampshire and the northern Connecticut valley are greatly clogged in this way; and it is in these deposits that the subsequent channeling of the rivers has formed the terraces for which the valleys are so well known. It is evident that these are dependent on the presence of large rivers, draining a considerable area of back country; and that condition was not fulfilled in Rhode Island. Smaller examples of a similar process are, however, abundantly represented here.

When a favorable climatic change began to melt away the ice sheet faster than it was supplied by creeping southward from its northern source, it must finally have lost that measure of thickness that enabled it to move, and thereafter it must have lain as a stagnant sheet of ice, slowly decaying away. The decaying ice probably lingered longest in the valleys where it was thickest, and beds of sand and gravel were washed around its remnant blocks by the streams from the rainfall, as well as from the slow melting away of the ice. These gravel beds often form plains of half a

square mile in area, and sometimes give names to villages built upon them, as Jamaica Plain, near Boston. The plains make smooth fields for cultivation, and the rich farm gardens of Arlington and Winchester, north of Boston, are thus located. Larger examples of similar plains are found in the broad expanse of sands southwest of Providence, and in the even more extended plains of the southern half of Cape Cod. The latter were formed by the overwash adjacent to the ice sheet, when it was making the terminal moraine of the Cape, just as the little plains by Arlington and Winchester were overwashed surfaces adjacent to the decaying ice blocks. These plains have an interest, not only from their curious origin, and from their relation to our occupation of the surface, but also because they are, with the salt marshes, the only examples of true plains in New England; it is only on their even surface, however limited, that we can here give our school children an idea of the extraordinary flatness of the marine plains of the south Atlantic states, or of the lacustrine plains in the west.

The association of ponds with the smaller plains of sand and gravel is very common in southern New England. While the last blocks of ice remained, their place was held free from gravel; when the ice-blocks melted, their place was taken by water. The greatest number of our ponds originated in this way, and not by glacial excavations of their basins.

On the final disappearance of the ice, the valleys of pre-glacial time were irregularly clogged by the rubbish that had been dragged and washed about. The effect of the terminal moraine on the course of the Pawca-

tuck river, has already been mentioned. If it were not for the gravel hills on the southern side of the river, its waters would not be turned past Westerly, and that active city would be less favorably situated. Another more striking case may be mentioned in the falls of the Blackstone river, by which the growth of Pawtucket and so many other manufacturing villages has been determined. This little river, attempting to take possession again of its valley, after the evacuation of the country by the ice sheet, found its former course so well hidden by sand and gravel rubbish that it frequently lost its way; it departed irregularly from its valley line, and here and there took a course that led it across rocky ledges. The loose gravel, down stream from any ledge, is soon cut down nearly to the level of the next ledge below, but the channel of the stream above the ledge cannot be deepened until the ledge itself is cut through. Thus the stream is characterized by a succession of almost level reaches enclosed by gravel terraces, and short rapids over rocky ledges. At the latter, dams have been built, and factory villages have sprung up.[1]

One of the best instances of this kind is found just across the border of Rhode Island, in the busy city of Fall River. Here the waters from Wautuppa pond turn westward across a slight depression in the

[1] The succession of events here summarized was more fully illustrated by a series of three paper relief maps; the first indicated the form of a normal valley, with the stream flowing along the axial line between rocky slopes; the second showed the effect of clogging the valley with an excess of sand and gravel filling up its trough to a considerable depth; the third presented the existing condition of our streams, with drift terraces and waterfalls.

enclosing hills, and descend rapidly to the Taunton river. Mills were early established on this water power, and the situation has proved so favorable, by reason of being on tide-water, that their number has now increased far beyond the capacity of the original falls. The chief occupation of the city, therefore, was determined by the overflow of Wautuppa pond across the hills. Now, on looking at this pond, it is clearly seen to extend southward, directly towards the west branch of the (so-called) Westport river, already mentioned as a bay enclosed by a bar. The divide between the pond and the bay is composed of glacial drift. Remove this obstacle, and Wautuppa pond would be drained, and along its bottom Wautuppa brook, as we might call it, would flow southward into what might then be called Wautuppa Bay. If the overflow of the pond were returned from its present accidental transverse outlet to a more normal former escape by a longitudinal valley, Fall River would have no excuse for being. We must, therefore, ascribe to glacial accidents not only the existence of ponds, and the diversion of rivers from their former courses, but also a considerable influence on the industrial development of New England.

On the Merrimack river we find Manchester, Lowell, and Lawrence, all similarly located at water powers. When the ice sheet melted away, the valley was clogged with the excess of gravel and sand that was washed into it. And now that the river is cutting its way again through this clogging of gravel, it has here and there lost its old course, and run astride of a ledge of rocks. At every such point, a fall of greater or less height is developed, and there a city springs up. In

the case of Lowell this is particularly interesting, because it is, in fact, a city built to order. Seventy years ago its site was occupied by country farms. The value of the water power was perceived by some far-sighted engineers and capitalists; they bought up the land, dammed the river, cut canals to lead the water to convenient factory sites, and to-day we see there a city of many thousand inhabitants.

On the Connecticut river we have, at Turner's Falls and at Holyoke, repetitions of the same significant relation. Every factory village situated on a New England stream is an instance of the same relation between human and glacial history, and I find in this alone an ample justification for including some mention of the ice sheet that once overcame us in the discussion of our physical geography. It is not enough to say that these cities are built at falls in their rivers; we must know why there are falls, and this cannot be known without considering the action of the ice sheet.

Let us now, as in the case of the sand bars and the shore cliffs, attempt to put the glacial drift back on the hillsides whence it was derived, and restore something of the picture of the country in the time before the ice. There are two ways of doing this. In one way we estimate the amount of drift lying over the country, and try to carry it back to the sources from which its rocks were derived, thus deepening the valleys in which the drift was generally left, and increasing by a moderate measure the height of the uplands from which much of the drift came. Another, and perhaps better, method of gaining illustration of the condition of the country before the ice came, is found by travelling southward

beyond the terminal moraine, where it crosses New Jersey and Pennsylvania. Here we may realize a matter that might at first escape our attention in the other picture, namely, the complete absence of ponds and lakes in the regions not visited by the ice. The contrast between the lacustrine drainage of New England, Canada, or Minnesota, and the entire absence of lakes in such southern states as Kentucky, Tennessee, and the Carolinas, is entirely dependent on the recent glacial invasion of the former, and the freedom from glacial action in the latter. The same contrast may be drawn between Scandinavia, Finland, and Scotland, on the one hand, and Central Germany, France, and southern England on the other, and for the same reason.

We must be careful, therefore, in restoring pre-glacial New England, to let all our streams flow without interruption and run in a continuous current from their source to the sea. We must, moreover, shift a number of the streams from their present accidental or transverse courses into a direction more accordant with the general northerly trend of the hills and valleys; as, for example, in the change from the present westward overflow from Wautuppa pond to the former southward flow of our hypothetical Wautuppa brook. The eastward flow of Pawtuxet river doubtless needs similar correction, and many of its headwaters may have flowed formerly directly southward to the sea. While we cannot make any perfect restoration of the pre-glacial aspect of the country, we can at least gain a good idea of the character of the changes by which the present country would be reduced to its former state,

and from this we can gain a better appreciation of the features of the country as they now exist, and of their difference from those of the states south of the glaciated area.

THE VALLEYS OF THE UPLAND.

Although the minor features of the present time differ in several respects from those of pre-glacial New England, the general plateau-like upland and the valleys which dissect it had then, essentially, the same forms as now. Our next inquiry concerns the origin of the valleys themselves. Most of these valleys follow the lines of weaker rock structures, leaving the harder rocks on either side to maintain the form of the plateau. The general relation of the smaller to the larger valleys, and of all to the south-eastern slope of southern New England, leads us to believe that the valleys here, as in general elsewhere, are the product of the wasting of the land under the destructive forces of the atmosphere. Rocks become loosened into soil, the rain falling gathers into streams, and the streams cut channels and carry away the fine sediment washed into them from the decaying surfaces on either side. No limit of time is set to this process, and our best means of inferring some measure of the period that has been spent upon it is by the results that have been accomplished. If we follow up the valley of the Blackstone northward from the bay at Providence, or the valley of the Thames northward from the Sound at New London and Norwich, or that of the Housatonic, further west, into the interior of Connecticut, we must be convinced in every case that all these valleys were made by wash-

ing away the waste from the land surface, and that they have been made under the leadership of the streams that still flow through them, or, at least, under the leadership of the streams that flowed through them in pre-glacial times. It should not be inferred that the whole valley is in any case, here or elsewhere, made by the stream; the stream carries away the waste that is washed into it, but the wasting and widening of the valley sides is a process that has taken place outside the stream channel. Accepting this conclusion, let us consider for a moment what form the region had before the erosion of the valleys was begun.

If the valleys that dissect the plateau were filled up, we should find that the continuity of the upland surface would be much more marked than it is at present. This is manifest enough where the plateau is cut only by narrow valleys, as in western Massachusetts; but in certain parts of our region, the wasting away of the weaker rocks has destroyed so broad an area of the ancient upland that one may fairly be somewhat skeptical of its former existence there. In the neighborhood of Boston, for instance, the so-called Boston basin lies at a decidedly lower level than that of the uplands which enclose it on the north, west, and south; within the limits of the basin there is no trace of the upland. Again, the broad depression of Narragansett Bay constitutes an extended interruption of the continuity of the even uplands on either side. Still more does the Connecticut valley lowland break the plateau. Its breadth is from fifteen to twenty miles, and it constitutes so broad and deep a depression that the two parts of the plateau on either side of it deserve

separate geographical names—the eastern and the western plateau. But however much hesitation the observer may, on viewing this broad depression, feel concerning its once having had a surface essentially even with the adjacent uplands, there are three sufficient reasons for holding to the belief in the former continuity of the upland surface.

The first of these reasons is the remarkable continuity of the sky line in the neighborhood of the valleys, a subject already referred to in a general way, but now deserving more particular attention. From any of the hills on which Boston or its suburbs are built, one may look around and see to the north and west a comparatively even sky line, although to the south the line is interrupted by the Blue Hill range. From the hills of Fall River, the view westward across the upper arms of Narragansett Bay discloses a sky line of remarkable uniformity, broken only in a faint way even by "that proud eminence," Mt. Hope. From the margin of either of the uplands that overlook the Connecticut valley lowland, the observer must be as much impressed with the evenness of the sky line beyond as with the vastness of the depression beneath him. It is not only that the upland surface, as represented by the sky line in these several regions, is accordant in each one of them; but that each one is only a part of the single upland, whose various heights fall into close accord when its general increase of altitude to the northwest is perceived. So widespread an accordance of altitude finds no rational explanation except one that develops the present uneven rolling country by the erosion of valleys in a once even upland, and that,

therefore, requires the former filling of all the valleys up to the level of the uplands themselves.

In the second place, all these broader interruptions of the upland by the wider valleys are, as has been intimated, closely associated with the occurrence of belts or areas of softer rocks; while the adjacent areas which still roughly maintain the level of the general upland consist of harder rocks. This is most distinctly seen in the case of the Connecticut valley lowland, which follows the belt of weak red sandstones and shales, famous for the fossil footprints that they preserve, across Massachusetts and Connecticut.

In the third place, our general knowledge of valley growth requires us to suppose that the valleys were once shallower, and their enclosing slopes less widely opened, until at first the valleys must have been faintly perceptible, and the upland almost continuous. Whatever doubt one may at first feel as to the former essential continuity of the upland, I believe this doubt will be entirely dispelled by an excursion over those parts of the region where it is better preserved, and a consideration in the field of the reasons here presented for thinking that the valleys now sunk below the upland have all been etched out from a surface that once extended far and wide close to the upland level. There has been a good advance made in the denudation of the upland mass; it has passed its youth, and entered its adolescence; its maturity and old age are yet to come.

The adolescent valleys of New England may be compared with the valleys of other regions in different stages of development. The narrow trench followed by the Red River of the North in its course along the

middle of the dead-level plains on either side is about as young a valley as we can find; the river has only just begun its work, and in the future the valley must become much deeper and wider. The gorge of the Niagara is an excellent example of an infantile valley; for, however we may marvel at the volume of its excavation, when expressed in such irrelevant human measures as cubic yards, we must admit that the gorge only marks the beginning of the valley whose gradual widening must in time consume the even-topped plateau on either side. The Grand Cañon of the Colorado is, in spite of its immensity, not an old valley, but only a precocious youngster: the great mass of the plateaus on either side is only faintly attacked as yet, and the cañon will not be a mature valley until the plateau is thoroughly dissected by branch cañons, and the cañons widen into valleys. All these valleys are younger than our New England valleys. As to older valleys than ours, I believe there are some among the ancient mountains of New Hampshire, New York, and North Carolina, but their proper consideration cannot be undertaken here.

If the explanation now given for our valleys be adopted, the origin of the upland in which they are cut will require examination; but, before considering this, certain peculiarities of the valleys in their present condition will need attention.

THE BAYS OF THE SHORE LINE.

If we follow down the valleys of eastern Connecticut to the Thames, we find that after its gathering streams of fresh water have united in a single river, the

river loses its normal character and becomes an estuary of the sea below Norwich. The valley slopes, however, continue to enclose the estuary below Norwich in essentially the same manner as they enclosed the river above Norwich. In the same way the valley of the Blackstone leads us down to the arm of Narragansett Bay that heads at Providence; the Taunton river becomes a tidal stream but a few miles below Taunton; it then widens rapidly, and becomes a true estuary before Fall River is reached.

Many other instances of the same kind might be given, all leading to the conclusion that the valleys of our rivers continue seaward below present sea level. Their extension in this form must be inquired into. There are two suggestions that may be made. The first is that the lower portions of the valleys may have been widened and deepened by the tides or by the shore waves; the second is that the lower portions of the valleys now below sea-level were formed by the ordinary process of valley making, when the land stood higher, and that since then they have been flooded by the sea, in consequence of a relative depression of the land. The means of discrimination between these two suggestions are so simple that no one can hesitate to choose in favor of the latter explanation. We have found that our seacoast is now becoming more and more regular, under the action of marine forces. The promontories are being cut back into sea cliffs, and the smaller bays have already been shut up by the growth of sand bars across their mouths. The production of long, branching bays, somewhat like Narragansett, might be possible in a region where the tides are

strong and the rocks are weak, but on our seacoast, and on most seacoasts, such large bays are not of marine origin. The narrow estuary of the Thames above New London is too well enclosed from the active forces of the sea to be ascribed to their action; and this conclusion is perfectly confirmed when we look at the similar but more emphatic cases of the Connecticut, the Housatonic, and the Hudson. The tide is felt in the Connecticut for thirty miles from its mouth; tidal undulations are felt in the Hudson as far as Albany, 150 miles north of New York city. In both cases the upward reach of tidal oscillation marks the distance to which the depression of the land has more or less completely drowned the valley and altered its occupant from a normal river to a long, narrow arm of the sea.[1]

To one who is not accustomed to consider the effects of changes of level on the topography of shore lines, the frequent mention that must now be made of submerged valleys and drowned rivers may seem, at first, to carry the process too far; but observation all around the world only confirms the conclusion here stated for our own region. A slight depression of the coast and a consequent drowning of the lower course of rivers is an extremely common occurrence. We have illustration of it in the gentle depression by which the mouths of the Thames of England, the Seine of France, and the Elbe of Germany have all been converted into estuaries before they reach the sea. We have a much

[1] Two relief maps were employed to exhibit a region dissected by ordinary valleys, and the same region depressed partly below sea level, so as to convert the lower part of its valleys into bays and estuaries.

stronger illustration of the same process in the deeper submergence of the mountainous coasts of Norway and of British Columbia and Alaska, where the valleys have been converted into deep fjords. Most of the harbors of the world depend for their protection from the sea on the drowning of some pre-existent river valley by a slow depression of the land. Rio Janeiro, Brest, Hong Kong, Nagasaki, Sydney, San Francisco, Vancouver, and many other important harbors have thus been produced.

Returning now to the case of Narragansett Bay, a peculiar consequence of the depression of the land and the flooding of the lower part of the valleys may be discerned. A river once drained the lowland of the bay, receiving various side streams in its trunk, and leading them all southward to the shore line of its time. This trunk river has disappeared; only its head branches remain in sight to us, and each of these now constitutes a river by itself.[1] An analogy is often made between a river-system and a tree, each having its trunk and its branches. We may now extend this analogy by noticing that both the tree and the river-system may be trimmed; but in the trimming of the tree, the smaller outermost branches are thrown away, and the trunk and the main branches are preserved; while, when a river-tree is trimmed by drowning, it is the trunk and main branches that disappear, and only the outermost branches survive. An example of this

[1] This change was illustrated in reverse order by changing the blackboard drawing of the state so as to exhibit the sea-bottom as land, and thus to gather all the streams that enter Narragansett Bay into a single trunk river.

may be seen in the case of the Baltic Sea. This depression is an old land valley, along whose axis a large river once flowed out across the platform of the North Sea, then a lowland, to the true basin of the Atlantic Ocean further west. The Baltic River received many branches from Sweden on the west, from Finland and Russia on the east, and from Germany on the south; but the river has now disappeared by drowning, and only its branches still remain to us.

The converse of this illustration applies in regions where the land has been elevated instead of depressed, thereby adding a portion of the sea-bottom to the land area. In such cases, all the rivers are extended mouthward; several previously separate streams may be united and reach the ocean through a single channel. This process has undoubtedly had frequent application in the rivers that flow from the mountains and piedmont zone of the Carolinas, across the former sea-bottom that now constitutes the coastal plain of our southern Atlantic slope; the wide opened valleys of the older upland area lead down to the narrower valleys of younger lowland. New England is, therefore, in this respect, as well as in many others, more like Sweden than like our southern states. The principle of contrast as well as the principle of likeness finds excellent application in this study, and the study of home geography thus leads to a better appreciation of geography abroad.

Mention has been made of the growth of our manufacturing cities at water-powers; the water-powers have been shown to result from a glacial invasion of New England, as significant in our geography as the

Norman invasion of Old England is in British history. Not less important in locating our commercial cities is the shifting of our shore line, and the consequent production of our harbors. Gloucester lies on the shoulders of a half-submerged hill; Salem and Portland possess superb harbors produced by the drowning of rock-bound troughs; Providence and Norwich lie midway on the original courses of their respective rivers; but at the head of the present drowning of their valleys.

In view of these explanations it must be concluded that while our valleys were in process of formation New England stood somewhat higher out of water than it now does. Its area at that time must have been decidedly greater than it now is; how much greater, none can say; but the loss that New England has suffered by the depression of its margin below the sea is surely of much greater value than the increase of area that it has subsequently gained by the deposition of morainic gravel heaps and overwashed sand plains along its borders.

The maritime margin of New England ought therefore to be regarded as a factor that varies under many controls. It has been shifted inland and made very irregular by the moderate depression of an adolescent plateau. The lower courses of the valleys are transformed into bays and estuaries; the interstream highlands stand out as promontories, and occasional isolated hills are cut off as islands. The irregular coast line thus determined has been, in certain regions already mentioned, built seaward by glacial action, an excess of material on the hills of the interior having

been dragged and washed along to fill up the shallow waters close to the shore, very much in the same way that we have on a smaller scale carried the materials of our gravel hills to broaden the Neck and fill in the Back Bay of Boston. Finally, the shore line thus located by inward shifting and outward building has been modified by the action of the waves in the manner described in the beginning of the essay. When thus apprehended, every feature of the coast is seen to have a peculiar history behind it, and every settlement on our coast is dependent in one way or another on the varied processes by which the coast line has been shaped.

THE NEW ENGLAND PLATEAU.

Let us now take up the postponed consideration of the once even upland in which the valleys of New England were etched. Few geographers may care to carry their inquiries so far back into the history of the land as we must now go, but I believe that a sufficient warrant can be found for this long excursion in the better understanding that we shall at the end of it have gained of the relations that exist between our country and other parts of the world.

The New England plateau consists for the greater part of hard, dense, foliated rocks, whose crystalline texture and deformed attitude are greatly different from the fragmental texture and horizontal position of rocks formed on the land or accumulated on the bottom of the sea. All explanations of crystalline texture, such as we are now concerned with, associate it

with slow processes of mineral change deep beneath the earth's surface. The excessively deformed, twisted, gnarled, and wrinkled condition of the foliated rocks also calls for crushing processes characteristic of mountain growth, and carried on under the heavy pressure of overlying rock masses. Both the crystalline texture and the wrinkled structure of the plateau rocks imply a former deep burial, and yet they are both now found at the surface of New England. This can be explained only by supposing that the present surface has been brought down to these once deep structures; that is, whatever unknown amount of overlying rocks once existed here, it has been worn away until the once deep-lying masses are revealed. If we may judge at all of the magnitude of the overlying mass by the scale of rock deformation exhibited in the plateau, we should be fully warranted in supposing that a mountain range, as lofty as the Alps of the present time, once rose above New England. However, there is little gained in attempting to measure in any close way the height to which old New England once raised its mountain heads. It is enough that the heads were once much higher than they are now, and that the plateau in its present denuded state represents the possible future of the Alps when they shall have been laid low, just as the Alps now represent the probable past of New England before it was reduced.

The question may now arise, how could so even a plateau as that which we believe existed before the valleys were eroded in it, have been produced by the denudation of an ancient mountain range? The answer is simple. The even surface of the plateau is the pro-

duct of the (almost) complete wearing away of the old mountain range, until it was reduced to a nearly featureless lowland close to sea-level. It seems at first venturesome to carry our suppositions back to what may appear to be a far-reached conclusion; but the more we examine the surface of the earth, the more fully persuaded are we that the forms of the present are in many cases deeply engraved on the forms of the past; and that many regions where lofty mountains once existed have been all but completely swept away by the slow but unceasing destructive processes of the atmosphere.

It is not necessary here to call in the aid of any other processes, such as the waves of the sea beating on the shore, or the grinding of an ice sheet; for the action of the weather alone would furnish soil to be washed down the slopes and carried away by the streams to the sea, and this accounts for the entire result, provided that time enough is allowed for its operation. We certainly have no reason to object to this proviso. If the reduction of rugged mountains to even lowlands of denudation were a rare process, we might not be required to consider it in school teaching; but even surfaces of this kind are found in many parts of the world. If such lowlands, however common in other parts of the world, were unknown at home, we might not be required to consider them in our study of New England. But when we find that the upland hills, the dominating feature of our New England geography, are but the remnants of precisely such a lowland of denudation, it behooves us to consider it and its origin with much attention.

We would, therefore, ask that an imaginary visit be made again to the hill nearest to our school houses, and that again a view of the enclosing horizon be taken. In spite of the extraordinary disorder of our rocks, we do not see a rugged, mountainous topography with sharp Alpine summits, such as must have characterized the region in the time following the period of deformation. The even sky line of our hills finds no intelligent relation to the structure of the region until it recalls to us a once continuous upland surface, and until that upland surface is recognized as the product of a long-continued cycle of denudation which reduced a young mountain range to an old lowland.

The hearer may properly raise a specific objection to the explanation thus stated. If it is supposed that our plateau surface represents an old lowland of denudation, down to which the weather and the streams wore away the ancient mountains, and below which the streams could not deepen their valleys, how is it that the valleys of to-day are sunk below the upland surface? The answer is, again, a simple one. We must suppose not only that the lowland was produced by denudation, but that, after it was denuded, it was gently inclined to the southeast. A part of its area was thus depressed beneath the sea, forming the submarine platform of the Gulf of Maine, that extends seaward toward the deeper waters of the Atlantic. Conversely, another portion of the lowland was at the same time gently uplifted to form our slanting New England plateau, and it can only be after and on account of this uplift that our present valleys have been made. It is important to recognize that the warrant for supposing

that the old lowland was tilted since it was denuded is found simply in the facts here referred to. They demand reasonable explanation; and no explanation but the one here outlined has been proposed for them. The explanation is simple; indeed, so simple that one who is unused to it may doubt its force; but it holds fast to the facts of observation; it serves admirably, in many other cases than ours, to give rational meaning to the forms of the land. It is truly fortunate for us that the explanation is so simple; for, otherwise, it could not be introduced in our teaching, as it now certainly may be.

When the old lowland still lay near sea-level, the old streams of the long cycle of denudation had done all the work that was then assigned to them; they ran on faint gradients and carried light loads to the sea. Yet the surface of the country at that time must not be considered an absolute level, like the almost geometrical plains of the Red River of the North, between Dakota and Minnesota, where it is said that the curvature of the earth may be detected in the same manner as at sea. The old New England lowland was merely a surface of moderate relief. It must have had gently rolling hills; here and there, eminences of a considerable height may have risen above it. These were relatively small unconsumed remnants of the former much greater mountains; and such remnants we now see in little Mount Hope, whose summit rises gently above the uplands at the head of Narragansett Bay; in the rocky hills of Gloucester, now half drowned on the eastern coast of Massachusetts; in the more commanding summits of the Blue Hill range, south of Boston;

and again, in Wachusett and Monadnock, rising to truly mountainous heights further inland.

But when the old lowland was tilted to the south-east, all the rivers of that part which was raised above sea-level were revived from the inactivity of their old age and set to work actively as rejuvenated streams. It is to the activity of the rejuvenated rivers in this second cycle of their life that we owe our present valleys; it is to the slight drowning of the coastal portion of these valleys that we owe our present bays and estuaries; it is to the addition of the morainic gravel-heaps and sand plains in these valleys that we owe the present irregular courses of our streams with their youthful lakes and waterfalls.

The uplifted lowland that constitutes our plateau is not limited to New England; it may be traced across south-eastern New York, where it makes the Highlands that are cut across by the superb gorge of the Hudson, into New Jersey, Pennsylvania, Maryland, and Virginia. It has been recognized among the mountains of North Carolina, although there, as in the White Mountains of New Hampshire, the denudation is by no means so nearly complete as in southern New England. Taken all together, I regard this uplifted and dissected lowland as the most important geographical feature of our Atlantic slope.

Two examples from Europe must suffice for foreign illustration of the dissection of an old lowland of denudation. The Highlands of Scotland possess an accordance of altitude that has led to the belief in their former continuity as a plateau; the plateau is regarded as an uplifted lowland of denudation in

which a great number of valleys have been eroded since the time of uplift. The plateau of the middle Rhine between Bingen and Bonn is, in many parts, especially in the Hunsrück and the Taunus, a well preserved upland, raised from its former position as a lowland of denudation, and now dissected by narrow gorges, of which that of the Rhine is well known.

Our rugged New England landscape therefore offers in its larger features an excellent example of composite topography. Its upland is the remaining portion of an old lowland carved during a former cycle of denudation; its valleys mark the adolescent stage of development reached in a later cycle, the change from the earlier to the later cycle being caused by a general tilting and warping of the region, whereby one part of its surface was uplifted. The drowned valleys along the coast mark an episode of depression late in the elapsed portion of the later cycle. The drift hills and gravel plains are the record of a peculiar accident—a glacial invasion—by which the normal advance of the cycle was for a time interrupted. These are the natural relations of our geographical features, and I believe that our plan of teaching should be closely in accord with them.

I should say perhaps a few words, in closing, as to how far the explanations and illustrations given above may be properly introduced into our schools. I believe, in the first place, that it is the plain duty of every teacher of geography, down even to the primary schools, to strive to attain at least the measure of knowledge of New England that is here sketched out. The teacher may have little occasion to use the knowl-

edge, especially in the lower grades; but the knowledge should be in mind as the essential foundation for the introduction of still simpler facts and relations. I maintain, in the second place, that practically all of the outline here given—and indeed a great deal more also—is within reach of most scholars in our grammar schools. The difficulty that children may encounter in studying physical geography according to this plan does not come from the inherent difficulty of the subject, but from the grave imperfections in our means of presenting it. I would have, if it were only possible, in every school a series of models much more extensive and much better made than the few rough relief maps that I have used here in illustration; and with these and other aids it would certainly be possible gradually to familiarize a class of children with the great variety and the simple relations of geographical forms, in accordance with some such scheme as is here presented. Such teaching might be made almost ideal in its reality and its value; and it is to such an ideal that we must strive.